

evacuation means for said plasma generation chamber and said processing chamber;

wherein a circumferential length L_g of said endless annular wave guide tube, a wavelength λ_g of the microwave in said endless annular wave guide tube, a circumferential length L_s of said dielectric member and a wavelength λ_s of the surface wave propagating in said dielectric member substantially satisfy a relationship:

$$L_g/\lambda_g = (2n+1)L_s/\lambda_s$$

wherein n is 0 or a natural number.

2. A microwave processing apparatus according to claim 1, further comprising magnetic field generation means.

3. A microwave processing apparatus according to claim 2, wherein said magnetic field generation means is adapted to control the magnetic field in the vicinity of the slots at a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

4. A microwave processing apparatus according to claim 1, wherein said substrate support means is provided at a position distant from a generation area of said plasma.

5. A microwave processing apparatus according to claim 1, further comprising means for irradiating the substrate to be processed with optical energy.

6. A microwave processing apparatus according to claim 5, wherein said optical energy includes ultraviolet light.

7. A microwave processing apparatus according to claim 1, further comprising high frequency supply means connected to said support means.

8. A microwave processing apparatus according to claim 1, wherein said wave guide tube is provided therein with a first dielectric material.

9. A microwave processing apparatus according to claim 1, wherein said wave guide tube is provided therein with a second dielectric material which is different from said first dielectric material.

10. A microwave plasma processing apparatus comprising:

a plasma generation chamber of which periphery is separated from ambient air by a dielectric member;

microwave introduction means utilizing an endless annular wave guide tube provided around said plasma generation chamber and having plural slots;

a processing chamber connected to said plasma generation chamber;

support means for a substrate to be processed, provided in said processing chamber;

gas introduction means for said plasma generation chamber and said processing chamber; and

evacuation means for said plasma generation chamber and said processing chamber;

wherein a central radius R_g of said endless annular wave guide tube, a wavelength λ_g of the microwave in said endless annular wave guide tube, a central radius R_s of the dielectric member and a wavelength λ_s of the surface wave propagating in said dielectric member substantially satisfy a relationship:

$$R_g/\lambda_g = (2n+1)R_s/\lambda_s$$

wherein n is 0 or a natural number.

11. A microwave processing apparatus according to claim 10, further comprising a magnetic field generation means.

12. A microwave processing apparatus according to claim 11, wherein said magnetic field generation means is adapted to control the magnetic field in the vicinity of the slots at a

magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

13. A microwave processing apparatus according to claim 10, wherein said substrate support means is so provided as to place the substrate at a position distant from a generation area of said plasma.

14. A microwave processing apparatus according to claim 10, further comprising means for irradiating the substrate to be processed with optical energy.

10 15. A microwave processing apparatus according to claim 14, wherein said optical energy includes ultraviolet light.

16. A microwave processing apparatus according to claim 10, further comprising high frequency supply means connected to said support means.

15 17. A microwave processing apparatus according to claim 10, wherein said wave guide tube is provided therein with a first dielectric material.

18. A microwave processing apparatus according to claim 10, wherein said wave guide tube is provided therein with a second dielectric material which is different from said first dielectric material.

✓ 19. A microwave plasma processing apparatus comprising:

25 a plasma generation chamber separated from ambient air
by a first dielectric material;

a processing chamber connected to said plasma generation chamber;

means for supporting a substrate to be processed, provided in said processing chamber;

microwave introduction means utilizing an endless annular wave guide tube provided around said plasma generation chamber and provided with plural slots;

means for introducing gas for said plasma generation chamber and said processing chamber; and
evacuation means for said plasma generation chamber and said processing chamber;

wherein an interior of said annular wave guide tube is filled with a second dielectric material which is the

40 same as or different from said first dielectric material.
20. A microwave processing apparatus according to claim
19, wherein a ratio of dielectric constants of said first and
second dielectric materials is approximately equal to a
reciprocal of a square of the ratio of a circumferential
45 lengths of said first and second dielectric materials.

21. A microwave processing apparatus according to claim 19, further comprising a magnetic field generation means.

22. A microwave processing apparatus according to claim 21, wherein the magnetic field in the vicinity of the slots has a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

23. A microwave processing apparatus according to claim 19, wherein said substrate support means is provided at a position distant from a generation area of said plasma.

24. A microwave processing apparatus according to claim

19, further comprising means for irradiating the substrate to be processed with optical energy.

19, further comprising high frequency supply means con-
60 nected to said support means.

✓ 26. A microwave plasma processing method utilizing a
microwave plasma processing apparatus comprising a
plasma generation chamber of which periphery is separated
from ambient air by a dielectric member; microwave intro-
65 duction means utilizing an endless annular wave guide tube
provided around said plasma generation chamber and pro-
vided with plural slots; a processing chamber connected to

said plasma generation chamber; support means for a substrate to be processed; provided in said processing chamber; gas introduction means for said plasma generation chamber and said processing chamber; and evacuation means for said plasma generation chamber and said processing chamber; adapted to effect a plasma process on said substrate by selecting a circumferential length L_g of said endless annular wave guide tube, a wavelength λ_g of the microwave in said endless annular wave guide tube, a circumferential length L_s of said dielectric member and a wavelength λ_s of the surface wave propagating in said dielectric member so as to substantially satisfy a relationship:

$$L_s/\lambda_s = (2n+1)L_g/\lambda_g$$

wherein n is 0 or a natural number.

27. A microwave processing method according to claim 26, wherein the plasma process is effected under application of a magnetic field.

28. A microwave processing method according to claim 27, wherein said magnetic field is so controlled that the magnetic field in a vicinity of the slots is at a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

29. A microwave processing method according to claim 26, comprising a step of placing said substrate on said substrate support means at a position distant from a generation area of said plasma.

30. A microwave processing method according to claim 26, wherein the plasma process is effected under irradiation of the processed substrate with optical energy.

31. A microwave processing method according to claim 30, wherein said optical energy includes ultraviolet light.

32. A microwave processing method according to claim 26, wherein the plasma process is effected by supplying high frequency to said support means.

33. A microwave processing method according to claim 26, wherein an interior of said wave guide tube is filled with a first dielectric material.

34. A microwave processing method according to claim 26, wherein an interior of said wave guide tube is filled with a second dielectric material which is different from said first dielectric material.

35. A microwave processing method according to claim 26, wherein said plasma process is film forming.

36. A microwave processing method according to claim 26, wherein said plasma process is etching.

37. A microwave processing method according to claim 26, wherein said plasma process is ashing.

38. A microwave plasma processing method utilizing a microwave plasma processing apparatus comprising a plasma generation chamber of which periphery is separated from ambient air by a dielectric member; microwave introduction means utilizing a cylindrical endless annular wave guide tube provided around said plasma generation chamber and provided with plural slots; a processing chamber connected to said plasma generation chamber; support means for a substrate to be processed; provided in the processing chamber; gas introduction means for said plasma generation chamber and said processing chamber, and evacuation means for said plasma generation chamber and said processing chamber, adapted for effecting a plasma process by selecting a central radius R_g of said endless annular wave guide tube, a wavelength λ_g of the microwave in said endless annular wave guide tube, a central radius R_s of said dielectric member and a wavelength λ_s of the surface wave propagating in said dielectric member so as to substantially satisfy a relationship:

$$R_s/\lambda_e = (2n+1)R_s/\lambda_e$$

wherein n is 0 or a natural number.

39. A microwave processing method according to claim 38, wherein the plasma process is effected under application of a magnetic field.

40. A microwave processing method according to claim 39, wherein said magnetic field is so controlled that the magnetic field in a vicinity of the slots is at a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

41. A microwave processing method according to claim 38, comprising a step of placing said substrate on said substrate support means at a position distant from a generation area of said plasma.

42. A microwave processing method according to claim 38, wherein the plasma process is effected under irradiation of the processed substrate with optical energy.

43. A microwave processing method according to claim 42, wherein said optical energy includes ultraviolet light.

44. A microwave processing method according to claim 38, wherein the plasma process is effected by supplying high frequency to said support means.

45. A microwave processing method according to claim 38, wherein an interior of said wave guide tube is filled with a first material.

46. A microwave processing method according to claim 38, wherein an interior of said wave guide tube is filled with a second dielectric material which is different from said first dielectric material.

47. A microwave processing method according to claim 38, wherein said plasma process is film forming.

48. A microwave processing method according to claim 38, wherein said plasma process is etching.

49. A microwave processing method according to claim 38, wherein said plasma process is ashing.

50. A microwave plasma processing method wherein a substrate is placed in a microwave plasma processing apparatus comprising a plasma generation chamber separated from ambient air by a first dielectric material; a processing chamber connected to the plasma generation chamber; means for supporting a substrate to be processed, to be placed in the processing chamber; microwave introduction means utilizing an endless annular wave guide tube provided around said plasma generation chamber and provided with plural slots; means for introducing gas for said plasma generation chamber and said processing chamber; and evacuation means for said plasma generation chamber and said processing chamber, wherein the interior of said annular wave guide tube is filled with a second dielectric material which is the same as or different from the first dielectric material, thereby effecting a plasma process.

51. A microwave processing method according to claim 50, wherein a ratio of the dielectric constants of said first and second dielectric materials is approximately equal to a reciprocal of a square of a ratio of circumferential lengths of said first and second dielectric materials.

52. A microwave processing method according to claim 50, wherein said plasma process is effected under application of a magnetic field.

53. A microwave processing method according to claim 52, wherein the magnetic field in a vicinity of the slots has a magnetic flux density approximately equal to 3.57×10^{-11} (T/Hz) times of a frequency of the microwave.

54. A microwave processing method according to claim 50, comprising a step of placing said substrate on said substrate support means at a position distant from a generation area of said plasma.

55. A microwave processing method according to claim 50, wherein the plasma process is effected under irradiation of the substrate with optical energy.

56. A microwave processing method according to claim 50, wherein the plasma process is effected by supplying high frequency to said support means.

57. A microwave processing method according to claim 50, wherein said plasma process is film forming.

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58. A microwave processing method according to claim 50, wherein said plasma process is etching.

59. A microwave processing method according to claim 50, wherein said plasma process is ashing.

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